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The Equity Differential Factor in Currency Markets

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We show that the differential in trailing equity market performance across countries strongly predicts the cross-section of currency returns. Specifically, exchange rates tend to appreciate for countries with the strongest equity returns in the preceding year. Portfolios formed on this factor have outperformed those formed on traditional carry, trend, and valuation factors in currencies since 1990. The equity differential factor cannot be explained by these traditional factors and produces a statistically significant alpha in excess of them. Its performance is remarkably consistent and robust to different formulations. We provide evidence that investor demand for outperforming equity markets probably contributes to this effect.

Disclosure: The authors report no conflicts of interest.

CE Credits: 2

The interest rate differential between two countries is a strong predictor of the future profits that result from a bet on their exchange rates. On average, spot exchange rates have failed to converge to the interest rate differentials implied by forward rates. This phenomenon is known as the "forward rate bias," and it underpins the historically profitable carry trade. The carry trade is implemented by entering into forward contracts to buy currencies of countries with high interest rates and sell currencies of countries with low interest rates. The total return of the trade equals the interest rate differential earned plus the return associated with any change in the spot exchange rate.

Although there is no consensus as to why exactly the carry trade works, two general possibilities have been noted. One is that interest rates adjust to compensate investors for the inherent riskiness of certain currencies. The other is that spot exchange rates rise more (or fall less) for countries with high interest rates, perhaps because these countries attract more investment or because they adjust to deliver a risk premium to investors. Either effect could lead to positive average carry returns.[1]

In the study reported in this article, we constructed an investment strategy that is conceptually similar to the carry trade, but we did not use interest rates. Instead, we based currency positions on the trailing 12-month equity index returns for each country. Note that *this strategy does not actually invest in any equities*; it uses equity index returns merely to indicate which currency positions to take. This "equity differential" strategy was implemented by entering into forward contracts to buy currencies associated with high recent equity returns and sell currencies associated with low recent equity returns. Just as the carry trade strategy does, the equity differential strategy generates a return that equals the interest rate differential earned plus the return of the spot rate. The interest rate differential is an unavoidable feature

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of speculation in currency forward contracts, but because we are not selecting currencies on the basis of their interest rate differentials, this component of return is likely to be small. The spot return is more relevant to our strategy. We found that currencies associated with high recent country equity returns subsequently outperform those associated with low equity returns. This result is surprisingly consistent and robust.

We noted that carry factor returns may arise because interest rates adjust up for riskier currencies or because their exchange rates tend to appreciate. We can apply the same logic to the equity differential factor. Suppose that long-run equity premiums are higher for some countries because of their inherent riskiness. Those countries will reward equity investors with higher local returns. How will the risk premiums of those countries affect currency returns? To the extent that currency risk and country equity risk are related, we might expect to see higher interest rates in the riskier country. The implication would be that the equity differential strategy is correlated with carry. We found, however, that the two strategies are almost perfectly uncorrelated.

What about the exchange rate story? Two scenarios are possible. First, to the extent that a rising equity market forecasts higher economic growth in a country, fundamental economic forces might lead to a subsequent appreciation of the currency. This logic is consistent with asset pricing models of exchange rate determination.[2] Second, the notion that spot rates increase because of high relative demand for a country's assets follows the same logic whether those assets are short-term interest-bearing instruments or equities. Either could increase the value of the currency. In the case of equities, this view implies that investor demand for equities is—either rationally or irrationally—partly based on recent performance. This implication is plausible in light of the strong empirical support for equity momentum. All else being equal, we expected an increase in demand to cause currency appreciation.[3] Moreover, we found that the equity differential strategy cannot be explained by currency momentum.

To the best of our knowledge, the equity-based currency factor we introduce has not been documented previously in the literature. Research in currency pricing and prediction has focused mostly on the interest rate differential, fair value equilibrium with purchasing power parity (PPP), and time-series trends of exchange rates. Indeed, these three factors have been shown to explain a large portion of returns generated by professional currency fund managers,[4] and their performance properties have been studied extensively (see, e.g., Hsu, Taylor, and Wang 2016, 2018). Most commonly, a country's exchange rate has been considered an input to explain or predict its equity market performance, not the other way around. Hau and Rey (2006) estimated the contemporaneous correlation of foreign currencies and equities to be negative from a US investor's perspective. These results may be highly specific to the US dollar, however, in light of its status as a global reserve and safe-haven currency (see, e.g., Lustig, Roussanov, and Verdelhan 2014). Furthermore, the relationships we found are not contemporaneous but occur in a lead–lag fashion from equities to currencies. Research has only recently begun to document a meaningful predictive link between country fundamentals and pairwise currency performance. Colacito, Riddiough, and Sarno (2018) showed that the difference in the output gap across countries, as a measure of relative economic conditions and the business cycle across countries, is predictive of future currency returns. Djeutem and Dunbar (2018) extended the notion of uncovered interest rate parity in currencies to uncovered "return parity," wherein the prospects of equity return and bond yields may both drive demand for a currency.

Our results are consistent with both Colacito et al. (2018) and Djeutem and Dunbar (2018) and build on this stream of research in three key ways. First, we show that widely available market prices of major equity indexes can be used in a simple manner to generate currency returns that are associated with local market and economic conditions across countries. Second, we focused our application on the large and liquid G-10 developed-market currency universe and applied a pairwise construction for implementable portfolios that applies to currency investors from any domicile. Third, we present results for a variety of practical formulations of the equity differential factor. We found that the factor is remarkably robust over time and robust to changes in parameters and construction.

In the remainder of the article, we first describe the portfolios we formed on the basis of the equity differential factor, and then, we relate their performance to other known currency factors. Next, we present panel regressions of currency returns regressed on equity differentials to further explore cross-sectional pricing relationships.

The Equity Differential Factor

We applied the approach of Czasonis, Pamir, and Turkington (2019) to create cross-sectional currency portfolios that are agnostic as to base currency. We analyzed the G-10 currency universe, which consists of the Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY), Swedish krona (SEK), Norwegian krone (NOK), New Zealand dollar (NZD), and US dollar (USD).[5] To construct the equity differential factor portfolio through time, at the end of each month, we proceeded as follows:

1. We identified all 45 currency pairs of the G-10 currencies.
2. We calculated the differential in trailing 12-month equity index total returns, denominated in local-currency units, as of the end of the previous month for each pair.[6] We omitted the immediately preceding month for two reasons. First, doing so is a conservative approach in terms of practical implementation. Second, doing so avoided the effect of any possible short-term reversals in one-month returns and conforms with the conventional "12 − 1" (12-month minus 1-month) construction for equity momentum signals.[7]
3. We reoriented (flipped) each currency pair to represent a positive equity differential.
4. We allocated equal weight to each pair (or, alternatively, for a subset of pairs with the largest size differential) and netted the currency exposures across pairs to arrive at a final set of currency weights. These weights represent a set of long and short exposures to various currencies.
5. We recorded the subsequent month's performance of the factor portfolio, under the assumption of implementation with one-month currency forward contracts.[8]
6. We moved to the next month and repeated these steps.

This method guaranteed that our results would be representative for any investor rather than be anchored arbitrarily to a specific base currency. The pairwise approach also created more nuanced portfolios than a simple ranking approach across the 10 currencies because some currencies could have more weight in the final portfolio than others after the pairwise positions were netted. We repeated the same portfolio construction process for the carry trade (ranking by interest rate differentials),[9] trend (ranking by the trailing 12-month currency spot return as of the end of the previous month), and the value factor (ranking by the negative of the trailing five-year currency spot return to reflect long-run mean reversion).[10]

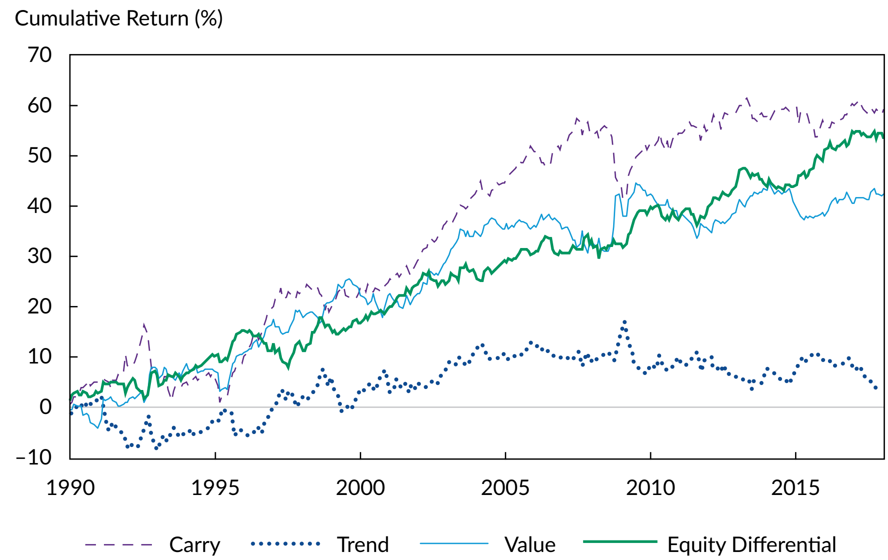
Table 1 shows the historical performance of the equity differential factor from January 1990 through December 2017. It had a higher return-to-risk ratio than any of the traditional strategies. Its risk, measured as annualized volatility, was lower in absolute terms than any of the other strategies, and it exhibited less downside risk as measured by the 5% worst outcomes. Although it had positive returns in

Table 1. Factor Portfolio Performance, 1990–2017

Measure	Carry	Trend	Value	Equity Differential
Annualized return	2.1%	0.1%	1.5%	1.9%
Annualized risk	4.0%	3.9%	3.8%	3.1%
Return-to-risk ratio	0.52	0.04	0.40	0.61
Percent positive months	62%	53%	55%	58%
Skewness	−0.75	−0.64	0.78	0.00
5% Worst year	−5.2%	−5.2%	−4.7%	−2.7%
5% Worst month	−2.0%	−2.0%	−1.5%	−1.3%
5% Best month	1.7%	1.6%	1.8%	1.6%
5% Best year	9.1%	5.5%	8.1%	6.1%

Note: Results for each strategy are based on 336 monthly observations for the returns of portfolios formed from 45 currency pairs.

Figure 1. Cumulative Returns, 1990–2017



Note: Based on 336 monthly observations for the returns of portfolios formed from 45 currency pairs.

58% of months, its monthly returns did not exhibit any skewness.[11]

Figure 1 shows each factor's cumulative returns. The equity differential factor has been remarkably consistent in its performance over time and continues to be one of the most effective and stable strategies of those depicted after the 2008 financial crisis.

Table 2 shows that the equity differential factor's correlations with other common factors is quite small from a portfolio investment perspective, at both the monthly and annual frequencies. In fact, two of the correlations have a negative sign. This outcome suggests that using the factor in combination with others can enhance risk-adjusted portfolio returns.

Table 2 also shows that the monthly correlations of equity differential with trend and with value, although small in absolute terms, are statistically different from zero.[12] To investigate these relationships more precisely, we regressed the monthly returns for the equity differential factor on those of the other three factors. As shown in **Table 3**, the R^2 of the regression is only 6%, and the annualized alpha, with a *t*-statistic of 3.12, is highly significant. All the other coefficients are close to zero, although the trend coefficient is negative and significant. This result is intriguing because the equity differential factor reflects a type of momentum in relative equity returns and the trend factor represents a similar type of currency momentum. This result reveals that currencies with a positive equity differential tend not to have a corresponding positive lagged currency

Table 2. Return Correlations, 1990–2017

	Monthly			Annual		
Factor Strategy	Carry	Trend	Value	Carry	Trend	Value
Trend	0.01			−0.04		
Value	−0.09*	−0.49*		0.00	−0.20*	
Equity differential	−0.03	−0.22*	0.19*	−0.13	−0.29*	0.12

Note: Based on 336 monthly observations for the returns of portfolios formed from 45 currency pairs.
*Significant at the 5% level.

Table 3. Regression of Equity Differential Factor Portfolio Returns on Other Factor Returns, 1990–2017

	Intercept[a]	Carry	Trend	Value
Coefficient	1.8%	–0.02	–0.13	0.09
t-Statistic	3.12	–0.41	–2.64	1.73
R^2	0.06			

Notes: Based on 336 monthly for the returns of portfolios formed from 45 currency pairs.

[a]Shown in annualized units; the *t*-statistic for the intercept pertains to monthly data.

return, which means the equity effect is distinct from the currency trend effect.

Figure 2 shows the long and short portfolio weights for the equity differential portfolio after netting the pairwise exposures. Panel A is a stacked chart that includes every weight; Panel B provides the weights for the Japanese yen and the British pound as examples. By virtue of the pairwise construction method, the exposures are quite diversified across currencies. They exhibit clear multiyear trends but no inherent biases toward one currency or another.

The impact of transaction costs on these trading strategies is important to consider. As shown in **Table 4**, the equity differential factor requires an

Figure 2. Equity Differential Factor Portfolio Weights, 1990–2017

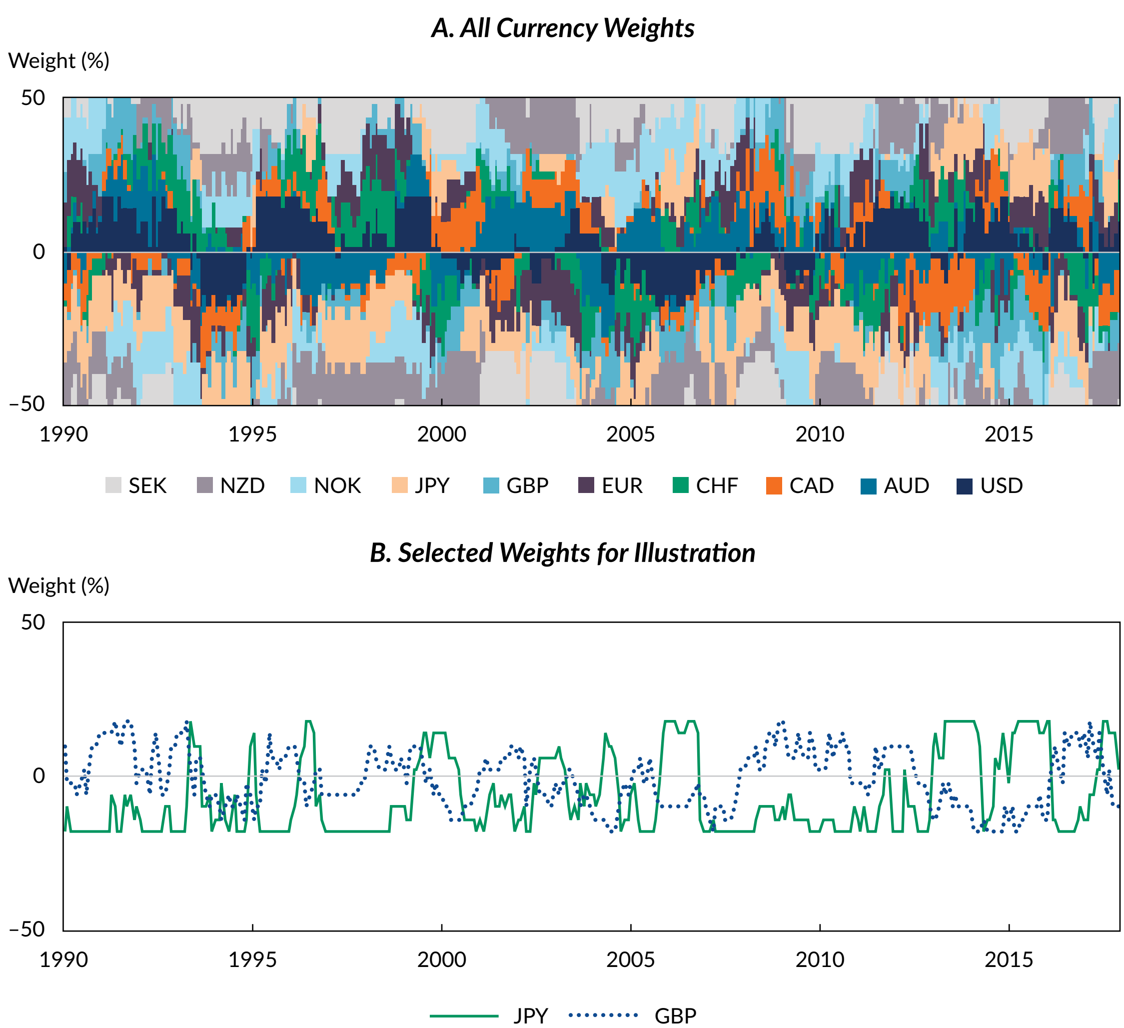


Table 4. Turnover and Performance Net of Estimated Trading Costs, 1990–2017

Measure	Carry	Trend	Value	Equity Differential
Average turnover (per year)	0.76	2.36	1.34	2.34
Breakeven costs (% per year)	2.76	0.06	1.12	0.81
Estimated actual costs (% per year)	0.05	0.14	0.08	0.14
Return (% after costs)	2.1	0.0	1.4	1.8
Risk (% after costs)	4.0	3.9	3.8	3.1
Return-to-risk ratio	0.51	0.00	0.38	0.57
Rescaled return (% after costs)	1.6	0.0	1.2	1.8
Rescaled risk (% after costs)	3.1	3.1	3.1	3.1
Rescaled return-to-risk ratio	0.51	0.00	0.38	0.57
t-Statistic (mean different from zero)	2.69	0.02	2.00	3.02
t-Statistic (mean different from carry)				0.23
t-Statistic (mean different from trend)				1.92
t-Statistic (mean different from value)				0.80

Notes: Based on 336 monthly observations of the returns of portfolios formed from 45 currency pairs.

average turnover of 2.3 times per year (selling the current portfolio and buying a completely different one equals a turnover of 1.0). This requirement is on par with the turnover of the trend strategy but larger than the turnover of carry and value.

Table 4 also shows the annualized return and risk of each strategy net of the estimated trading costs. Given that these strategies are self-financing and may be obtained with any level of notional exposure, we next rescaled the historical return series of carry, trend, and value to match the annualized volatility of the equity differential factor. We used the rescaled returns to present *t*-statistics for a test of whether each strategy's return is different from zero and also whether the equity differential factor's average return is significantly different from the average returns of the other strategies. We found that the equity differential had the highest rescaled return and the highest *t*-statistic on a standalone basis. Using paired *t*-tests for differences in means, we could not statistically reject the hypothesis that the equity differential factor's risk-adjusted return is comparable to that of carry or value. Nonetheless, we judge that these strategies complement each other well because of their previously shown low correlations.

Robustness Tests

Table 5 presents the results of additional robustness tests of the benefits of the equity differential factor. Our base-case equity differential factor included all 45 currency pairs in the portfolio each month, and a 12-month look-back window was used to compute the equity differential for each pair of countries.

First, we varied the number of pairs included in the portfolio. Each currency was included in 9 of the 45 pairs, so when we picked 27, at least 3 different currencies had to be in the long basket and the short basket. When we picked 9 pairs, a single currency could compose the entire long or short basket, but in that case, the opposite basket had to be diversified across the other 9 currencies. We also tested a version that selected the single pair with the largest equity differential. The strategy return rises as fewer pairs were selected, which indicates that the signal became stronger in the tails. Of course, the resulting portfolios were also less diversified, so the volatility rises and, in general, the return-to-risk ratio drops. Although we have not presented the full robustness test results for carry, trend, and value here, we based them on the same parameter specifications for comparison. In every case, the equity differential factor had the highest return-to-risk ratio. We also

Table 5. Robustness Tests, 1990–2017

		Number of Pairs			Absolute Threshold			Look-Back Window	
		Top 27	Top 9	Top 1	> 5%	> 10%	> 15%	45 Pairs	45 Pairs
	Base Case: 45 pairs,	Months			Months			Months	
Measure	12 Months	12	12	12	12	12	12	6	18
Test result									
Return	1.9%	2.4%	3.6%	4.2%	2.3%	2.8%	2.9%	2.1%	1.6%
Risk	3.1%	4.4%	6.5%	9.6%	3.8%	4.6%	5.7%	3.4%	3.0%
Return-to-risk ratio	0.61	0.54	0.55	0.43	0.59	0.60	0.50	0.63	0.54
Regressions against carry, trend, and value									
Intercept[a]	1.8%	2.1%	3.1%	3.7%	2.2%	2.6%	2.6%	2.0%	1.6%
t-Statistic	3.12	2.53	2.55	2.04	3.10	3.00	2.46	3.17	2.67

[a]The intercept is shown in annualized units. The *t*-statistics for the intercept pertain to monthly returns.

repeated the regressions from Table 3, and we report in Table 5 the annualized intercept and its *t*-statistic. The intercept comprises nearly all of the excess return of the factor in every case, which means it cannot be explained by the other factors. It becomes less significant because of higher noise in the more concentrated portfolios, but the *t*-statistic remains above 2.0 even in the case of one pair.

Next, we imposed a fixed threshold for the size of the equity differential. As with the previous test, the return rises for higher thresholds, but risk also rises and the ratio degrades slightly.

Finally, we varied the look-back window used to compute trailing country equity returns while keeping the pair selection fixed at 45. The results do not change much for a 6-month or an 18-month window instead of a 12-month window, although the performance is slightly stronger for the shorter window. Again, in every instance, the equity differential factor has a higher return-to-risk ratio than the carry, trend, and value factors.

Panel Regressions and Tests to Attribute the Economic Effect

The results presented so far were based on implementable portfolios invested in one-month forward contracts and formed on the information available at each point in time. In this section, we analyze the predictive relationship between each of the pairwise currency variables underlying the factors and the next month's spot return for each currency pair. We performed this analysis as a panel regression that included observations for each currency pair each month for a total of 15.120 observations from January 1990 through December 2017. Performing the test this way allowed us to assess the collective power of the equity differential factor to predict various currency pairs in a similar fashion. We included various combinations of time fixed effects and currency-pair fixed effects to evaluate the variables' predictions in the cross-section and through time.

Our choice to include all 45 currency pairs in the panel regression—as opposed to selecting one base currency—benefited the regression analysis by increasing the number of observations, by reflecting pairwise differences for each combination of countries, and by avoiding any arbitrary anchor to a specific base currency. Accounting for the fact that these observations are not independent from one another, however, is important. Each currency is included in nine pairs, so the observations will be correlated across pairs by construction. This correlation did not bias the coefficient estimates, but it will bias the conventional estimates of standard errors if they are not adjusted. Thus, we computed standard

Table 6. Panel Regression Results, 1990–2017

	I		II		III		IV	
Time fixed effects:	No		No		Yes		Yes	
Currency pair fixed effects:	No		Yes		No		Yes	
	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic
Equity differential	0.010	2.10	0.011	2.37	0.010	2.05	0.011	2.34
Interest rate differential	−0.282	−0.70	−0.013	−0.02	−0.273	−0.70	0.037	0.06
12-month prior currency return	0.006	0.58	0.006	0.53	0.007	0.64	0.006	0.57
60-month prior currency return	−0.010	−1.83	−0.012	−2.10	−0.010	−1.80	−0.012	−2.07
R^2	0.79%	—	1.05%	—	8.60%	—	8.86%	—

Notes: Based on 15,120 monthly observations for 45 individual currency pairs. The standard errors used to compute *t*-statistics were adjusted to account for correlation of residuals across currency pairs.

errors and *t*-statistics that adjusted for the correlation of errors across every combination of currency pairs.[13]

The panel regression results are shown in **Table 6**. The equity differential is a positive and statistically significant predictor of future spot returns both in the cross-section and through time. The interest rate differential is a weak negative predictor for the spot rate, which means that spot returns tend to be negative for higher-interest-rate currencies. (The interest rate differential earned in the carry trade, which is not represented here, more than makes up for the losses in the spot return, which is why the carry trade factor works.) Lagged 12-month currency returns are a weak positive predictor, and lagged five-year currency returns are, in general, statistically significant and negative, denoting a tendency for mean reversion in currency values. In the second regression, currency pair fixed effects—which are essentially "intercept" or constant terms that apply individually to each pair—account for the average performance differences across pairs, so the variable coefficients from this regression mostly pertain to time-series predictions of each variable. Similarly, in the third regression, time fixed effects—which are essentially "intercept" or constant terms that apply individually to each month in the sample—account for average variation in currency performance across time (such as broad shifts in global risk conditions), so the variable coefficients from this regression mostly pertain to the cross-sectional predictions of each variable. The R^2 is substantially higher in this case.[14]

The key result in Table 6 is that the equity differential is a positive and statistically significant predictor of future exchange rate movements after controlling for the effects of carry (the interest rate differential), trend (the 12-month prior currency return), and value (the 60-month prior currency return). This result confirms the findings of the portfolio tests shown in Table 3.

We have not yet distinguished between two possible explanations for the equity differential factor. One explanation related to *return-chasing behavior* is that price pressure from investors seeking outperforming equity markets pushes up currency values. Another possible explanation is that stock markets anticipate future economic conditions, which, in turn, drives fundamental demand for currencies. If return-chasing behavior causes currency appreciation, we should observe a stronger effect when subsequent equity returns align with the trailing equity differentials and a weaker effect when subsequent equity returns oppose their trailing differentials.

In other words, to test for this explanation, we treated the alignment of future equity returns with trailing equity differentials as a proxy for the strength of momentum trading in cross-country equity markets. We split the equity differential variable into two parts: one equal to the variable times a dummy variable for positive alignment with future one-month equity differentials and the other equal to the variable times a dummy variable for negative alignment. Given that we were now conditioning on future one-month equity differentials that occur contemporaneously with the currency returns, we also included the future one-month equity differentials themselves as a control. Our goal with this regression was to observe, with full hindsight of equity performance, whether the currency returns that follow lagged equity differentials occur disproportionately when equity values also rise.

If, to the contrary, currencies tend to rise even in the presence of subsequent negative equity returns, *prediction of fundamentals* may be the more likely explanation.

Table 7 presents the results of this test. It shows that both equity differential coefficients are positive,

Table 7. Equity Differential Effect Conditional on Subsequent Equity Returns, 1990–2017

Time fixed effects:	Yes	
Currency-pair fixed effects:	Yes	
	Coefficient	*t*-Statistic
Equity differential when contemporaneous equity returns align	0.018	2.79
Equity differential when contemporaneous equity returns oppose	0.005	0.73
Interest rate differential	0.120	0.21
12-month prior currency return	0.001	0.14
60-month prior currency return	–0.013	–2.19
Contemporaneous equity returns	–0.127	–5.29
R^2	11.65%	—

Notes: Based on 15,120 monthly observations for 45 individual currency pairs. The standard errors used to compute *t*-statistics were adjusted to account for correlation of residuals across currency pairs.

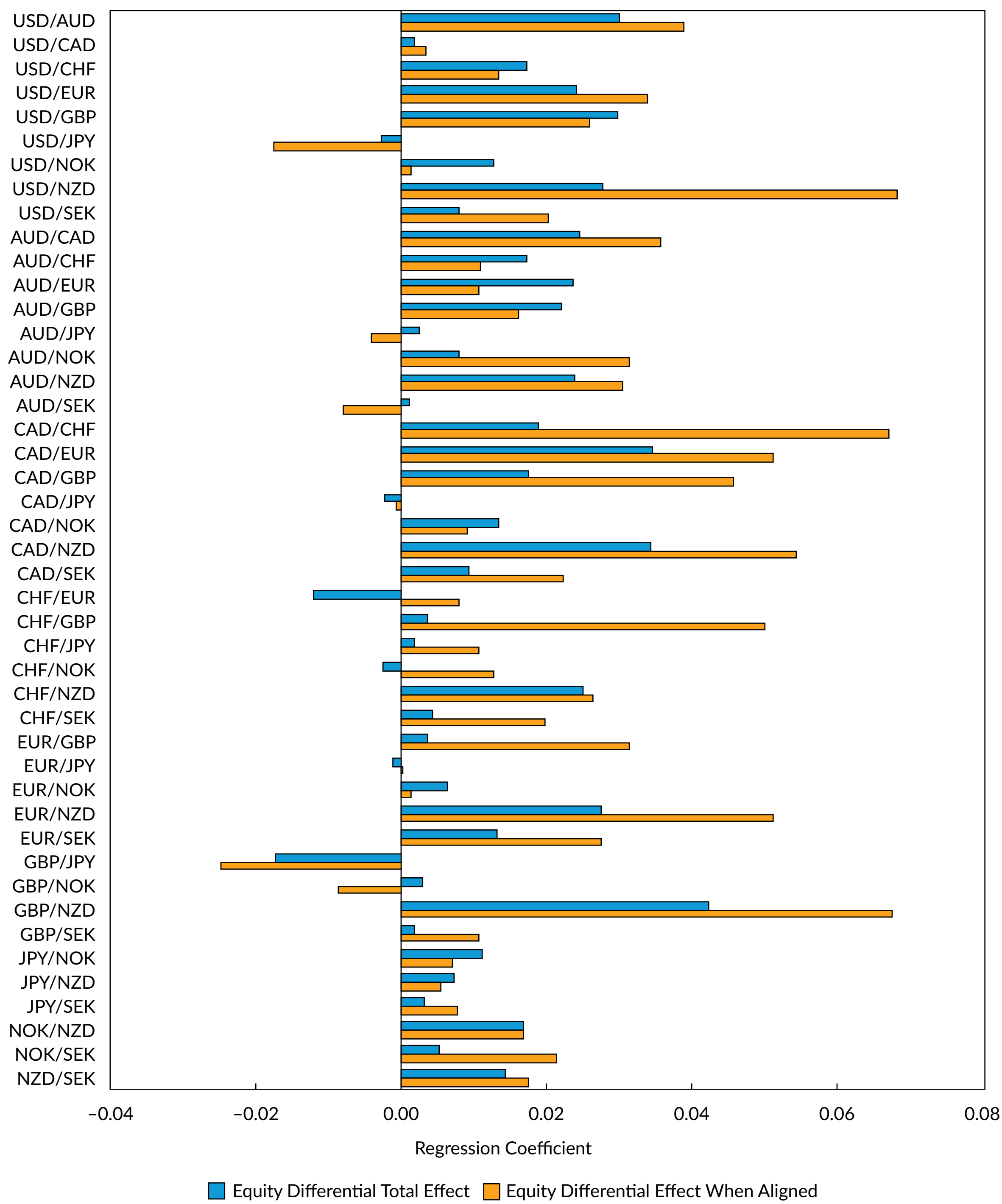
but the coefficient for aligned returns is nearly four times stronger and far more statistically significant than the other coefficient. This result does not rule out the possibility that equity differentials anticipate fundamentals, but it does suggest that differences in equity demand play an important role.

Figure 3 reports the effect for each currency pair based on time-series regressions of each pair in isolation. The dark blue bars show the equity differential coefficient from the regression specification of Table 6 applied to each pair individually, and the orange bars show the equity differential coefficient when contemporaneous equity returns align using the specification from Table 7. Note that, despite the noise inherent in analyzing individual pairs, the overall relationship is positive for 39 of the 45 pairs. Overall, the relationship is weakest for pairs that contain the Japanese yen. For many pairs, the result intensified when it was conditioned on the alignment of future equity returns. Interestingly, we did not find any strong evidence connecting momentum-driven price pressure to the size of a country's equity market or its total amount of international trade. Although a greater price impact might be expected from an equal amount of capital chasing returns in small countries versus big ones, more capital might also be focused on the larger markets. Therefore, the effect may not necessarily be more significant for small countries. For example, the equity differential factor appears to work quite reliably for the US market.

Conclusion

Trading rules in currencies and equities have been studied extensively, but evidence of strong links between the two markets is rare. Nevertheless, we found that the differential in recent equity market performance across countries offers a strong and consistent prediction of next month's currency returns. This equity differential factor can be implemented easily and practically in an investment via ranked currency portfolios in developed markets. It is highly distinct from the traditional carry, trend, and value factors that are commonly applied to currency investing and has outperformed them all in risk-adjusted terms since 1990. A substantial portion of the return predictability appears to align with demand from cross-border equity momentum, although the anticipation of country fundamentals may also play a role.

Figure 3. Attribution of Effects by Currency Pair, 1990–2017



Notes: Based on 15,120 monthly observations for 45 individual currency pairs.

Editor's Note

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Notes

1. The literature on the carry trade and its possible explanations is extensive. For further discussion of these issues, see, for example, Hodrick and Srivastava (1984), Burnside (2012), and Dobrynskaya (2014).

2. See, for example, Sarno and Taylor (2003) and Krugman and Obstfeld (2003).

3. This effect is consistent with the findings of Froot and Ramadorai (2005, 2008) that institutional portfolio flows are associated with short-term momentum effects in the exchange rate.

4. See Pojarliev and Levich (2012) for details.

5. We used the German mark to proxy for the euro prior to the euro's introduction in 1999.

6. We used MSCI equity index total returns for the relevant country or region. For the euro, we used the European Monetary Union equity index when available and the German index before 1999. Using a consistent set of indexes representing highly investable large-capitalization stocks provided a simple and robust measure of equity performance. Alternative country equity indexes tend to have high correlations with other large-cap proxies, so we did not expect the choice of index to affect our analysis in any material way (for example, the S&P 500 Index and Dow Jones 30 annual returns were 99.9% and 95.1% correlated, respectively, with the MSCI USA Index during the time period of our analysis).

7. Removing this one-month lag had little effect on the results. The risk-adjusted return of the equity differential factor is 0.61 with the lag and 0.58 without the lag.

8. We used the WM Reuters 4 p.m. London midrates for spot rates and one-month-forward prices.

9. We ranked by interest rate spreads implied by forward rates; we simply divided the forward exchange rate by the corresponding spot exchange rate. The result equaled precisely the return an investor would realize if the spot return was zero for the investment period.

10. We performed the analysis with a more precise definition of currency valuation based on the PPP implied from spot returns and official government inflation rates based on consumer price indexes. The two value/reversion factors are similar and did not affect the results. We chose to focus on the simpler version, which is based on only trailing five-year currency returns.

11. An equally weighted allocation to the four strategies in Table 1 has a return-to-risk ratio of 0.93.

12. The annual observations were computed from overlapping 12-month rolling returns. The use of rolling windows added precision to the estimates and did not bias them. We could not, however, use a simple *t*-statistic to assess the significance of the annual correlations. We performed a numerical simulation of two uncorrelated variables to evaluate the significance of these estimates.

13. We adjusted *t*-statistics on the basis of the variation implied by the observed correlation in errors across all currency pairs in the sample. The conventional calculation for estimates of the standard error of coefficients assumes that errors are uncorrelated across all observations and thereby diversify each other to reduce total expected variation. To the extent that errors are positively correlated, total expected variation is larger than assumed by independence. We computed the variance of errors—and, by extension, the standard errors of coefficients—by assuming the correlations in errors across currency pairs equaled the relevant observed time-series correlations of the regression residuals across every pair of currency pairs (there were 45 currency pairs and 990 pairwise combinations of them) in the panel. In other words, we explicitly accounted for the fact that prediction errors in USD/AUD will be partly overlapping with prediction errors in the eight other USD pairs and the eight other AUD pairs (as well as potentially the pairs that did not include either of these currencies explicitly). Mathematically, the variances of the beta coefficient estimates, $\hat{\beta}$, equals the diagonal entries in the matrix given by $\text{var}(\hat{\beta}) = E\left[(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{u}\mathbf{u}'\mathbf{X}(\mathbf{X}'\mathbf{X})^{-1}\right]$, where $\mathbf{X}$ is a stacked matrix of panel data observations and $\mathbf{u}$ is a column vector of errors. We used ordinary least squares to estimate beta coefficients, which were unbiased. We could not rely on conventional estimates of $\text{var}(\hat{\beta})$, however, because they assume the errors are uncorrelated. Instead, we estimated this variance as $\hat{\sigma}_u^2(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\hat{\mathbf{C}}\mathbf{X}(\mathbf{X}'\mathbf{X})^{-1}$, where $\hat{\mathbf{C}}$ is a matrix of estimated correlations for each pair of observed residuals in the panel regression. For pairs of observations that did not correspond to the same time period, we assigned a value of zero to the expected correlation of residuals. For pairs of observations that did correspond to a given time period t, we assigned the time period correlation between those currency pairs' residuals over all T observations, $\text{corr}(\hat{u}_i, \hat{u}_j)$. This approach is conceptually the same as the well-known Newey–West standard errors correction, but it was adapted to our specific panel regression setting. For more information on this estimation procedure, we refer the interested reader to the appendix of Czasonis, Kritzman, and Turkington (2019).

14. We note for robustness that for a much less powerful but simpler test of 45 individual time-series regressions in which we used the same model specification from Table 6, 39 had positive *t*-statistics for the equity differential factor (versus about 23 that would be expected by chance), and 12 had *t*-statistics greater than 2 (versus about 2 that would be expected by chance). The combined test is more powerful and relevant, and its adjusted *t*-statistics are consistent with the findings of these individual time-series regressions.

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